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# THE EFFECTS OF PNEUMOPERITONEUM ON LUNG FUNCTION IN PULMONARY EMPHYSEMA

BY

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The treatment of chronic hypertrophic emphysema by pneumoperitoneum has received much favourable comment in recent medical literature. In several reports on small series of cases it is claimed that this manœuvre will increase vital capacity (Brackenridge and Jones, 1953; Furman and Callaway, 1950; Gaensler and Carter, 1950; Zak and Southwell, 1953), maximum breathing capacity (Gaensler and Carter, 1950; Kory, Roehm, Meneely, and Goodwin, 1953), and intrapulmonary mixing efficiency (Gaensler and Carter, 1950), reduce residual volume (Gaensler and Carter, 1950; Kory and others, 1953; Zak and Southwell, 1953), and in some cases improve the ability to maintain a normal arterial oxygen saturation on effort (Furman and Callaway, 1950; Gaensler and Carter, 1950). Furthermore, in 30 out of the 43 cases reported in the literature clinical improvement has closely paralleled improvement in the tests of lung function.

This paper is a report of the effects of pneumoperitoneum on lung function tests in 11 emphysematous subjects.

## MATERIAL AND METHODS

Eleven cases of chronic hypertrophic emphysema of varying severity were selected for study. The diagnosis was initially made on clinical and radiological grounds and was supported by lung function tests in each case (Table I).

The tests included spirometry before and after an antispasmodic drug, with measurement of vital capacity (V.C.) and maximum breathing capacity (M.B.C.) and comparison of these values with predicted values for each patient (Baldwin, Cournand, and Richards, 1948); an estimate of functional residual capacity (F.R.C.) using a closed circuit constant volume apparatus of the type described by McMichael (1939) with certain modifications (Briscoe, Becklake, and Rose, 1951); calculation of residual volume (R.V.) and total lung capacity (T.L.C.); and comparison of these values with predicted values (Baldwin and others, 1948); estimation of mixing efficiency using an index of the type described by Becklake (1952) with correction for pulmonary deadspace (Becklake and Goldman, 1954); estimation of arterial oxygen saturation* at rest and after effort; and an estimation of red cell count, haemoglobin, and alkali reserve.

Patients were studied for an average period of 93 days (range six to 328 days) before the induction of a pneumoperitoneum during which period they received treatment with antibiotics, antispasmodics, and various forms of physiotherapy until it was thought that maximal improvement had been obtained. The function tests were repeated on several occasions (mean 5, range 3 to 13) during this preliminary observation period. In Table I the cases are arranged in order of clinical severity, the first two being the mildest and the last three bedridden. It will be seen that the group includes varying degrees of abnormality and that the pattern of abnormality is typical of "emphysema,"—for example, reduction in maximum breathing capacity, increased residual volume, impaired intrapulmonary mixing, and fall in arterial oxygen saturation on effort. Venous congestion was not a feature of any case at the beginning of the trial.

Pneumoperitoneum was induced while the patients were in hospital. One or two refills were carried out in hospital, and subsequently the pneumoperitoneum was maintained in the out-patient department for a mean period of 13 weeks (range two to 24 weeks). During this time lung function studies were repeated at intervals of two to four weeks, and again after the complete absorption of the pneumoperitoneum in most cases. In Case 1, the pneumoperitoneum was allowed to absorb after nine weeks, and was then re-induced for a further 12 weeks. Thus, two sets

* Waters-Conley absolute reading oximeter.

TABLE I

RESULTS OF LUNG FUNCTION TESTS BEFORE AND AFTER INDUCTION OF PNEUMOPERITONEUM

| Case | Age (years) | % Predicted Value | | | | % Lung Capacity | | Oxygen Saturation of Arterial Blood Determined by Oximetry | | Mixing Index | Blood Studies | | | Subjective Improvement |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | V.C. | M.B.C | R.V. | T.L.C. | F.R.C. | R.V. | At Rest (%) | Fall after Exercise (%) | | Red Cells (m./ml.) | Hb (g./100 ml.) | Alkali Reserve (ml./ 100 ml.) | |
| 1 | 55 | 100 | 90 | 194 | 131 | 74 | 47 | 86 | −7 | 3·05 | 5·37 | 16·2 | 56 | |
| (a) | | 94 | 76 | 214 | 135 | 68* | 52 | 68 | −7 | 2·57* | 5·28 | 15·8 | 57 | Moderate |
| (b) | | 95 | 85 | 196 | 130 | 68* | 50 | | | 2·22* | | | | " |
| 2 | 76 | 101 | 49 | 226 | 136 | 71 | 51 | 87 | −2 | 3·52 | 4·51 | 14·4 | 49 | |
| | | 109 | 69* | 171* | 138 | 61* | 44* | | | 2·81 | | | | None |
| 3 | 57 | 76 | 46 | 196 | 119 | 71 | 53 | 87 | −8·5 | 4·41 | 5·24 | 16·5 | 61 | |
| | | 72 | 45 | 186 | 119 | 72 | 54 | ? | −5 | 5·62 | 5·89 | 18·1 | 53 | Moderate |
| 4 | 56 | 81 | 26 | 254 | 140 | 79 | 56 | | | 3·43 | | 16·3 | 58 | |
| | | 81 | 26 | 246 | 137 | 76 | 54 | | | 6·26 | | | | " |
| 5 | 49 | 63 | 40 | 202 | 101 | 77 | 52 | | | 3·57 | | | | |
| | | 76 | 63 | 244 | 125 | 67 | 51 | | | 6·26 | | | | " |
| 6 | 42 | 75 | 20 | 182 | 114 | 81 | 52 | 92 | −8 | 4·1 | 7·33 | 22·4 | 72 | |
| | | 72 | 28 | 214* | 133* | 81 | 52 | | | 6·73* | | | | " |
| 7 | 56 | 76 | 38 | 268 | 147 | 74 | 60 | | | 8·11 | 6·32 | 18·7 | 52 | |
| | | 72 | 38 | 264 | 139 | 78 | 63 | | | 10·0 | | | | None |
| 8 | 62 | 72 | 37 | 222 | 111 | 78 | 62 | | | 5·58 | 5·55 | 16·4 | 53 | |
| | | 70 | 40 | 218 | 127 | 78 | 60 | | | 2·88 | | | | Marked |
| 9 | 49 | 47 | 20 | 507 | 170 | 83 | 78 | 92 | −15 | 4·43 | 5·63 | 17·5 | | |
| | | 50 | 23 | 486 | 165 | 80 | 76 | | | 4·58 | 5·84 | 18·2 | 64 | Moderate |
| 10 | 61 | 82 | 24 | 236 | 136 | 76 | 57 | 81 | −10 | 8·02 | 5·50 | 17·9 | 63 | |
| | | 75 | 25 | 193 | 121 | 75 | 53 | | | 8·05 | | | 58 | " |
| 11 | | 58 | 18 | 340 | 162 | 79 | 70 | 72 | −14 | 2·41 | 6·19 | 20·5 | 67 | |
| | | 55 | 15 | 283* | 134* | 81 | 70 | 88 | −7 | 2·85 | | | 67 | Marked |
| Normal limits(1) .. | | 76–138 | 41–93 | 76–239 | 85–141 | 49–67 | 11–39 | | −4(2) | 1·43–3·43 | | | | |

(1) Normal limit (mean ± 2 S.D.) for each test based on observations by Becklake and Goldman (1954) at this altitude.
(2) Normal range based on observations by van Lingen and Whidborne (1952).
* Significantly different from value before pneumoperitoneum ($p < 0.05$ by Fisher's t-test).
For each case the first line refers to the best result obtained during the three weeks before induction of pneumoperitoneum, and the second to the best result obtained during maintenance of the pneumoperitoneum. In Case 1, pneumoperitoneum was instituted on two separate occasions, and lines (a) and (b) refer to the best results obtained during these two periods.

of comparative studies were done in this case, making 12 sets in the 11 cases.

## RESULTS

For the purposes of comparison the best overall test result (i.e., the most normal) on any one occasion in the three weeks before pneumoperitoneum was compared with the best overall test result on any one occasion during the period when the pneumoperitoneum was adequately maintained. (It is these two results which are recorded in that order for each case in Table I.) Scrutiny of these results shows no striking trend towards improvement or deterioration in the group as a whole. For individual cases where there appeared to be some change in any one test Fisher's t-test was used to compare the best post-pneumoperitoneum result with the mean of the pre-treatment results (Yule and Kendall, 1944). Pneumoperitoneum was thus assessed in terms of the best results it could produce, and in the calculation of t-values the best post-pneumoperitoneum test result was handled as if it were the mean of the post-pneumoperitoneum series. Comparatively low levels of probability ($<0.05$) were considered significant.

With this statistical handling of the data, which was biased to favour the treatment, one case (No. 2) showed significant improvement in four tests and two cases (Nos. 1 and 11) significant improvement in two tests each (Table I). In the two mildest cases (1 and 2) there was a significant reduction in the state of inflation of the lung (reduced ratio of F.R.C. to T.L.V.) and improvement in intrapulmonary mixing, although in Case 2 the fall in mixing index was not quite within the stated limits of significance ($p=0.056$). One patient (Case 6) showed significant deterioration in three tests.

Objective clinical improvement was not apparent in any case. Subjective improvement, however, was reported in all except Case 2 (who showed the greatest improvement on tests) and Case 7. Case 6, whose test results showed deterioration, claimed moderate subjective benefit from the treatment.

## DISCUSSION

Clear, objective evidence of improvement could only be demonstrated in one of 11 cases in this study, with possible slight improvement in two other cases, and definite deterioration in one other. This

result is disappointing when compared with the encouraging reports of this form of therapy which have appeared in the literature. Review of our methods reveals no obvious reason for this discrepancy. The cases studied were clinically typical chronic hypertrophic pulmonary emphysema of varying degrees of severity, uncomplicated by heart failure. Although Zak and Southwell (1953) found the milder type of case responded better, other workers (Brackenridge and Jones, 1953; Furman and Callaway, 1950; Gaensler and Carter, 1950) were satisfied that good results could be obtained in the severe case. The amount of air introduced and the frequency of refills was less than that used by Furman and Callaway (1950) and by Zak and Southwell (1953), but comparable to the series of Gaensler and Carter (1950). Gaensler and Carter (1950) stated that maximal improvement in some cases could only be expected after some months of treatment, but their results show that measurable improvement could be observed within 17 days. In our series pneumoperitoneum was maintained for from 12 to 169 days (mean 87 days) during which time any improvement which the treatment could produce should have been observable in the tests done.

The most striking difference between this series and most of those reported in the literature lies in the method of judging improvement in the lung-function tests. We have frequently observed the manner in which practice may produce improved values for tests such as vital capacity and maximum breathing capacity, and probably more important than this the way in which severity of symptoms (and results of function tests) fluctuate from week to week in any emphysematous subject (Becklake, McGregor, Goldman, and Braude, 1954). There is thus a reasonable chance that a series of tests carried out on any two occasions will demonstrate "improvement" or "deterioration." It is only in the light of repeated testing before the beginning of the treatment to be assessed, with an estimation of the range of fluctuation for each test, that changes after the start of therapy can be assessed. The comparison of two tests, one carried out before and the other after the start of therapy, as reported by many workers, seems an inadequate method of assessment. Only in the series of Zak and Southwell (1953) and the present series has an effort been made to observe the range of pre-treatment fluctuations.

Unlike most observers, we failed to show correlation between subjective improvement and improvement in test results. One must either conclude that pneumoperitoneum improved some aspect of function other than those tested, such as alveolo-capillary exchange, or that the tests were not sufficiently sensitive to detect minor changes in function, or that the feeling of improvement was purely psychogenic in origin. Unfortunately oximetric studies could only be repeated in three subjects after the induction of pneumoperitoneum (Cases 1, 3, and 11) where no improvement was evident. However, observers who report improvement in alveolo-respiratory function (Kory and others, 1953) demonstrate parallel improvement in ventilatory function. It can only be concluded from our results that, after a procedure designed to improve ventilation of the lung, tests of ventilatory efficiency showed no striking improvement except in one case. It seems probable that the subjective benefit reported by most of our patients was the result of a new and active form of therapy in individuals who suffered from a chronic incapacitating disease.

The only other workers who report failure to produce objective evidence of improved lung function following pneumoperitoneum in the severe forms of chronic hypertrophic emphysema were Zak and Southwell (1953). They suggested and demonstrated its value, however, in the milder type of case. Our own observations of improvement in the two mildest cases is in accordance with this claim.

## SUMMARY

Eleven cases of chronic hypertrophic emphysema were treated by pneumoperitoneum. Nine patients reported varying degrees of symptomatic relief; two experienced no improvement in their symptoms.

Pulmonary function was estimated on numerous occasions before and during treatment using a wide selection of tests of ventilatory function.

Only one case showed significant improvement in more than two tests. This subject reported no accompanying symptomatic improvement. Two other cases showed significant improvement in two tests with moderate symptomatic response. A fourth case showed significant deterioration but claimed satisfactory symptomatic improvement. There was thus no correlation between symptomatic improvement and improvement in objective tests of lung function.

Our results do not support previous reports that pneumoperitoneum is frequently a useful treatment in severe chronic hypertrophic emphysema. They do not, however, disprove the claim that it may be of use in the milder case.

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## ADDENDUM

Since the preparation of this paper Mann and Murphy (1954) have described a study of the effects of pneumoperitoneum on vital capacity and maximum breathing capacity in 10 emphysematous subjects. They found that only one patient showed consistent improvement symptomatically and in maximum breathing capacity while the pneumoperitoneum was maintained.

## REFERENCES

Baldwin, E. de F., Cournand, A., and Richards, D. W. (1948). *Medicine, Baltimore*, **27**, 243.
Becklake, M. R. (1952). *Thorax*, **7**, 111.
—— and Goldman, H. I. (1954). *S. Afr. J. med. Sci.*, **19**, 21.
—— McGregor M., Goldman, H. I., and Braude, L. (1954). In the press.
Brackenridge, R. D. C., and Jones, A. T. (1953). *Brit. med. J.*, **1**, 1135.
Briscoe, W. A., Becklake, M. R., and Rose, T. F. (1951). *Clin. Sci.*, **10**, 37.
Furman, R. H., and Callaway, J. J. (1950). *Dis. Chest*, **18**, 232.
Gaensler, E. A., and Carter, M. G. (1950). *J. Lab. clin. Med.*, **35**, 945.
Kory, R. C., Roehm, D. C., Meneely, G. R., and Goodwin, R. A. (1953). *Dis. Chest*, **23**, 608.
Lingen, B. van, and Whidborne, J. (1952). *Circulation*, **6**, 740.
McMichael, J. (1939). *Clin. Sci.*, **4**, 167.
Mann, B., and Murphy, E. A. (1954). *Thorax*, **9**, 87.
Yule, G. U., and Kendall, M. G. (1944). *An Introduction to the Theory of Statistics*, 13th ed. Griffin & Co., London.
Zak, G. A., and Southwell, N. (1953). *Acta med. Scand.*, **147**, 79.